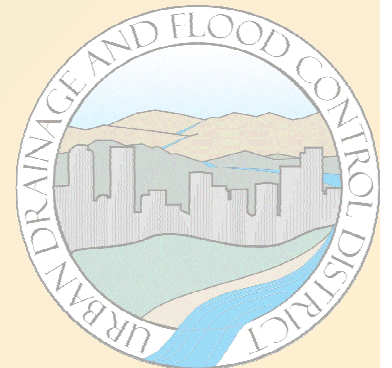


# UDFCD Stormwater BMP Monitoring Program

Holly Piza, P.E.



# Urban Drainage and Flood Control District

Established by  
CO legislature

1969

7 Counties

32 Cities &  
Towns

1600

Miles of  
Drainageways

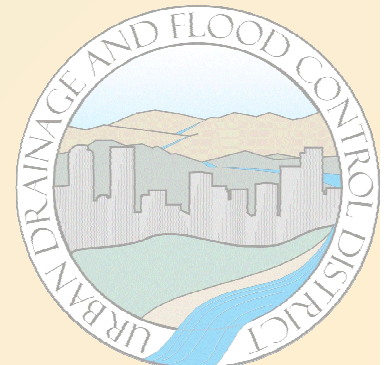
1608  
Area (sq mi)

15

Inches of  
Rain  
Annually

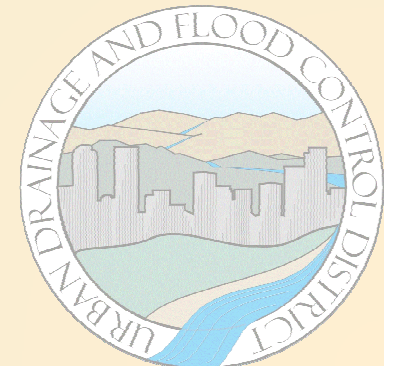
2.8

Million people living in the district



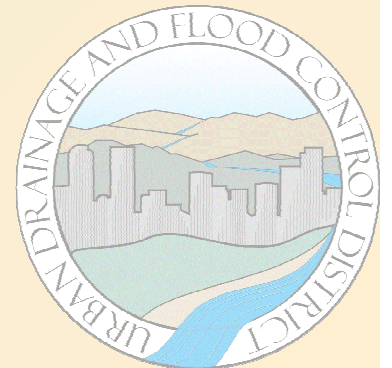
# More on that 15 Inches

Total Rainfall Depth (inches)	Average Annual Number of Storm Events	Percent of Total	Percentile of Runoff- producing Storms
0.0 to 0.1	46	61.07%	0.00%
0.1 to 0.5	22	29.21%	75.04%
≤ 0.6	69	91.61%	80.00%
0.5 to 1.0	4.7	6.24%	91.07%
1.0 to 1.5	1.5	1.99%	96.19%
1.5 to 2.0	0.6	0.80%	98.23%
2.0 to 3.0	0.3	0.40%	99.26%
3.0 to 4.0	0.19	0.25%	99.90%
4.0 to 5.0	0.028	0.04%	100.00%
> 5.0	0	0.00%	100.00%
<b>TOTAL:</b>	<b>75</b>	<b>100%</b>	<b>100%</b>



# BMPs Monitored

- ❖ Extended Detention Basin
- ❖ Constructed Wetland Basin
- ❖ Sand Filter
- ❖ Pervious Concrete
- ❖ Porous Asphalt
- ❖ Permeable Interlocking Concrete Pavers
- ❖ Rain Garden and Green Roof Coming Soon!





# Rain Gages

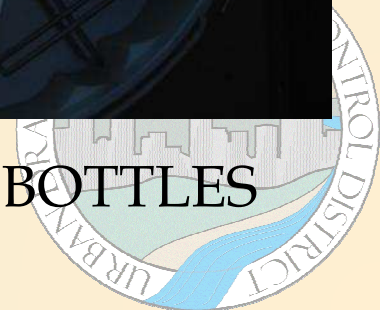




ISCO SAMPLER



COLLECTION BOTTLES

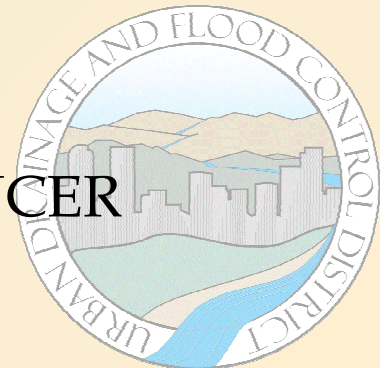




## LEVELOGGER



## PRESSURE TRANSDUCER





# Extended Detention Basin

Spring 2002





## Agreement between the Bowles Metro District and the Bow Mar Homeowners Association







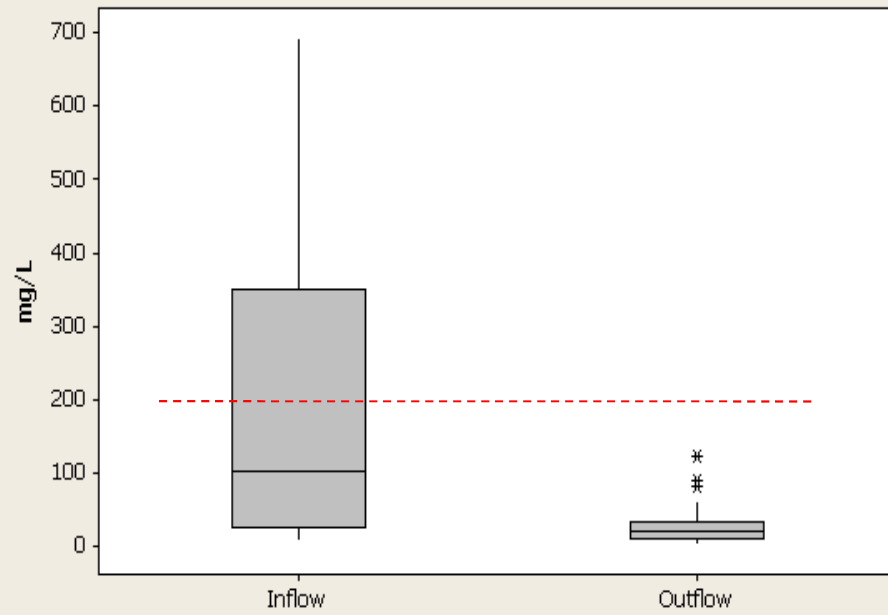
Boulder-edged micropool



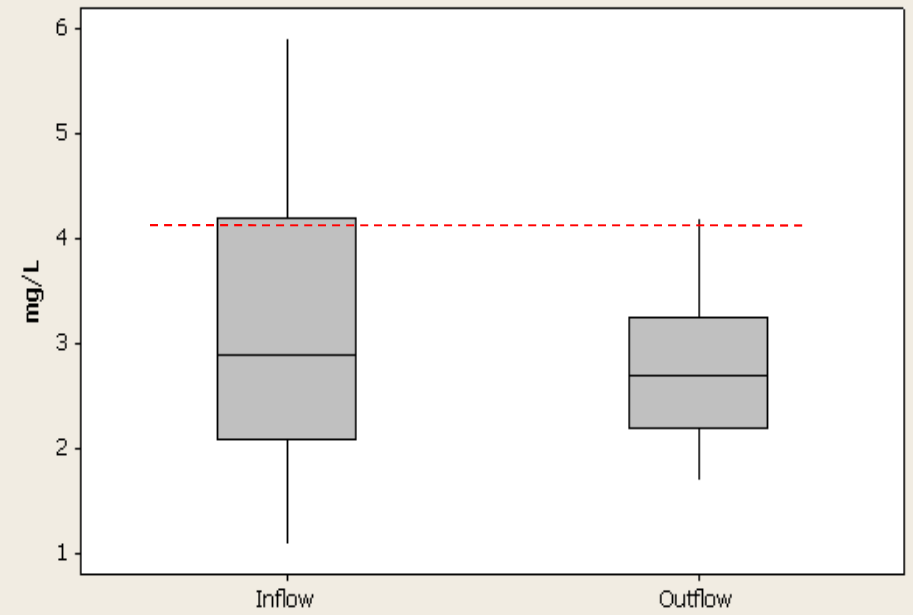
Outlet structure



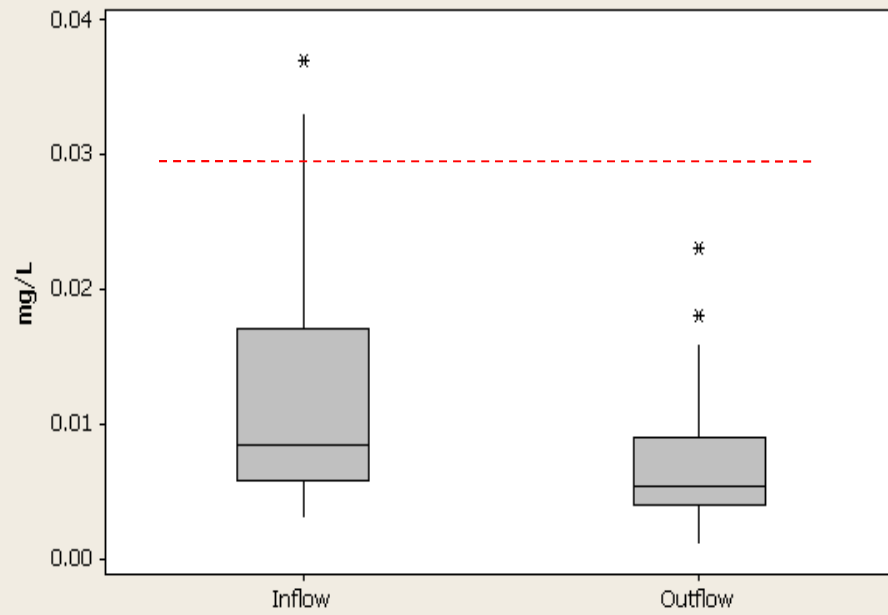
### Total Suspended Solids



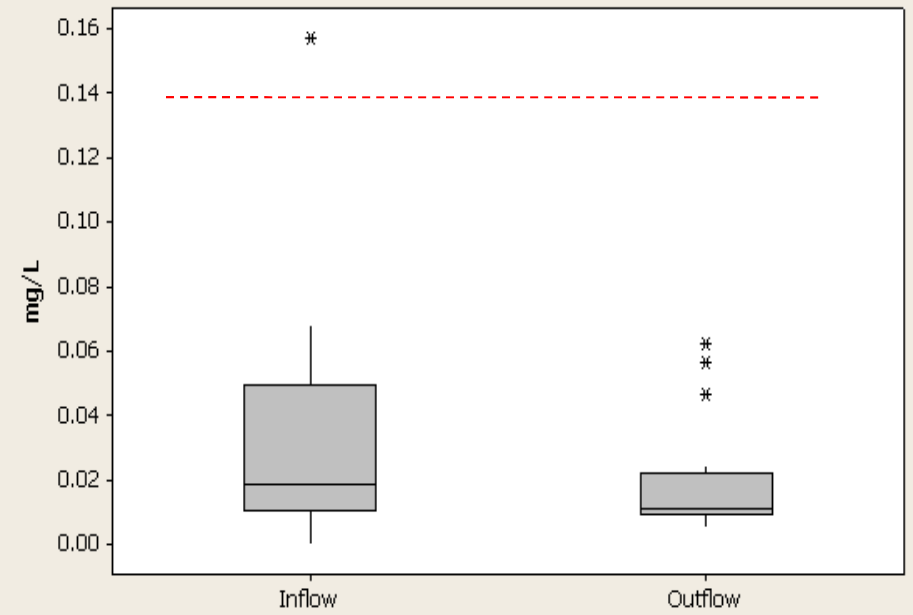
### Nitrogen



### Copper



### Zinc





# Constructed Wetland Pond

Spring 2009











Week 1



Week 2



Week 5



Week 6



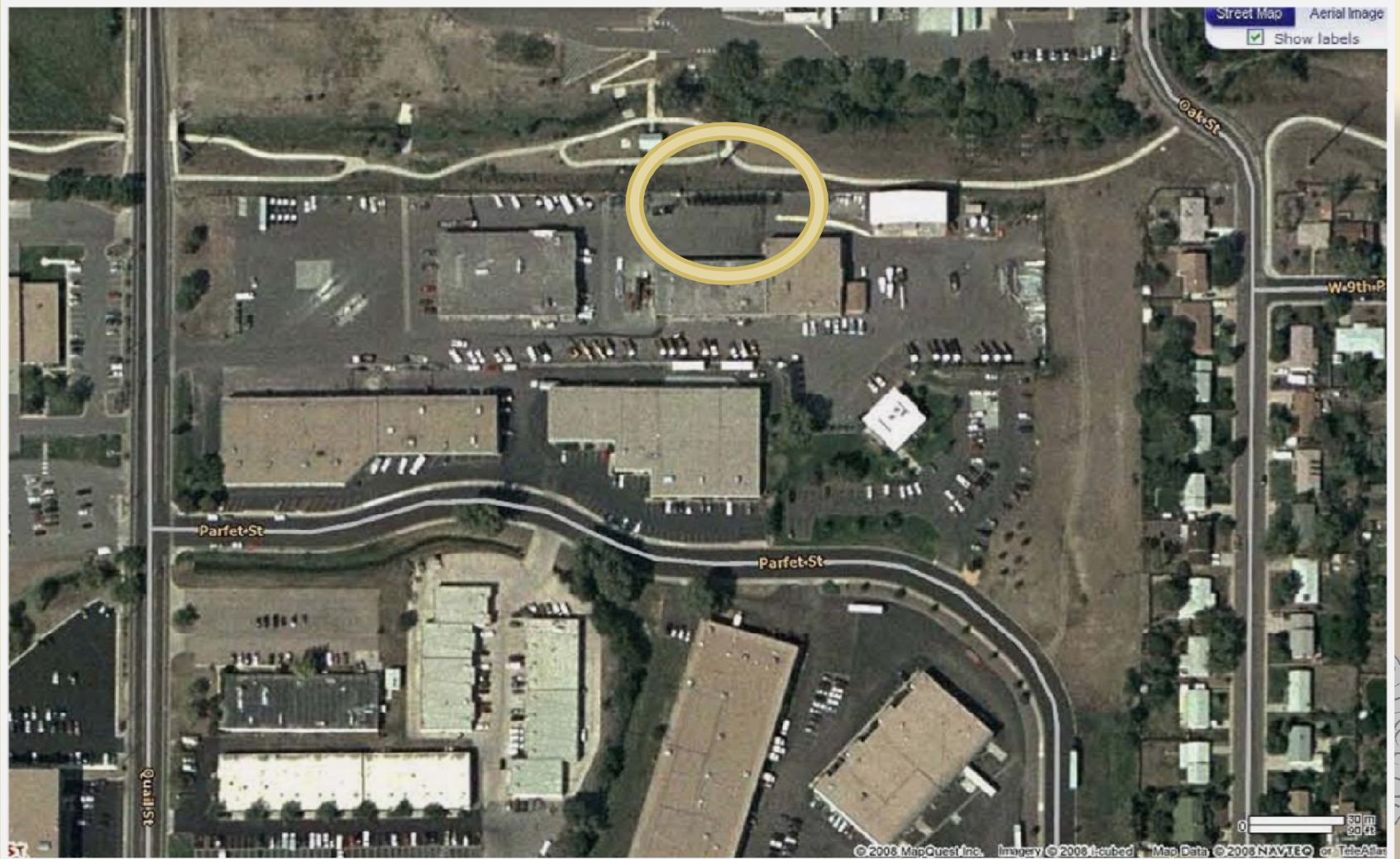


# SAND FILTER

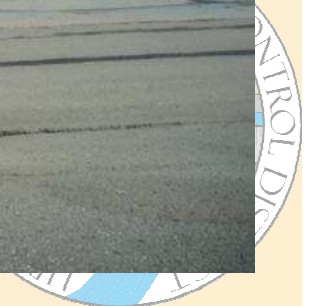
Spring 2007



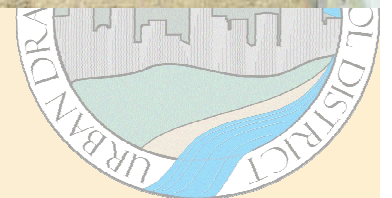
# Municipal Maintenance Facility









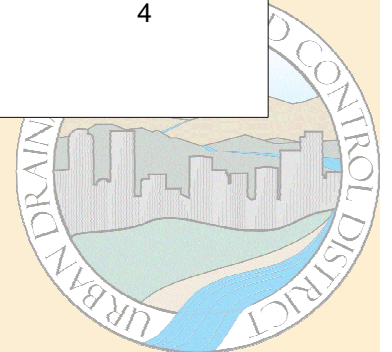
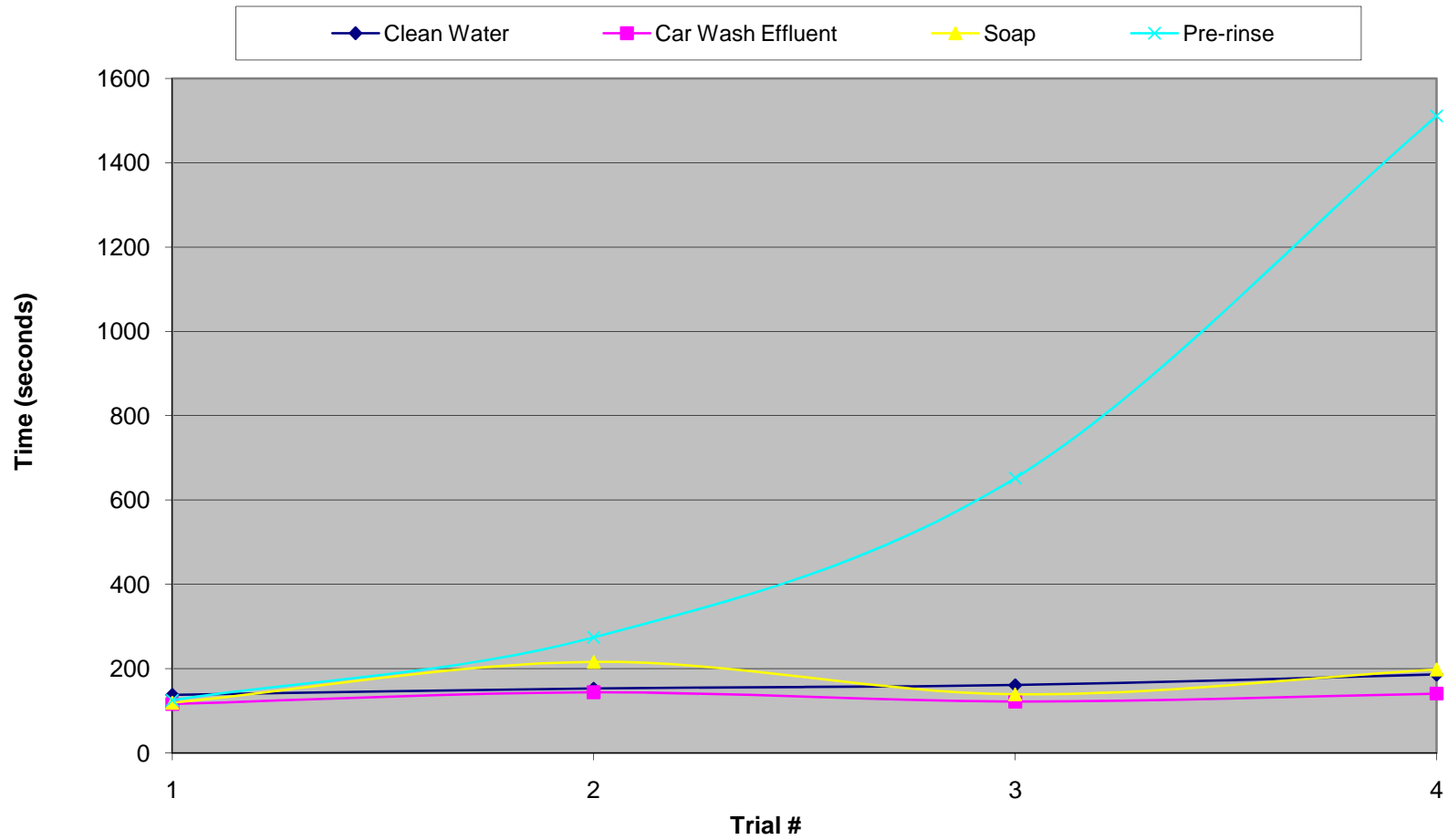






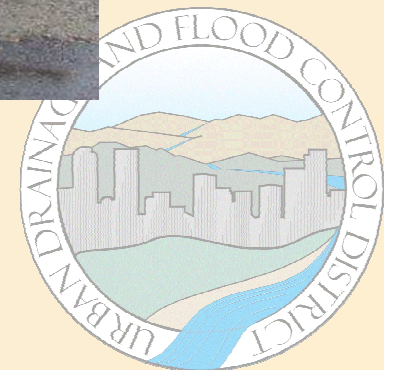


## Sand Filter Clogging Experiment Results

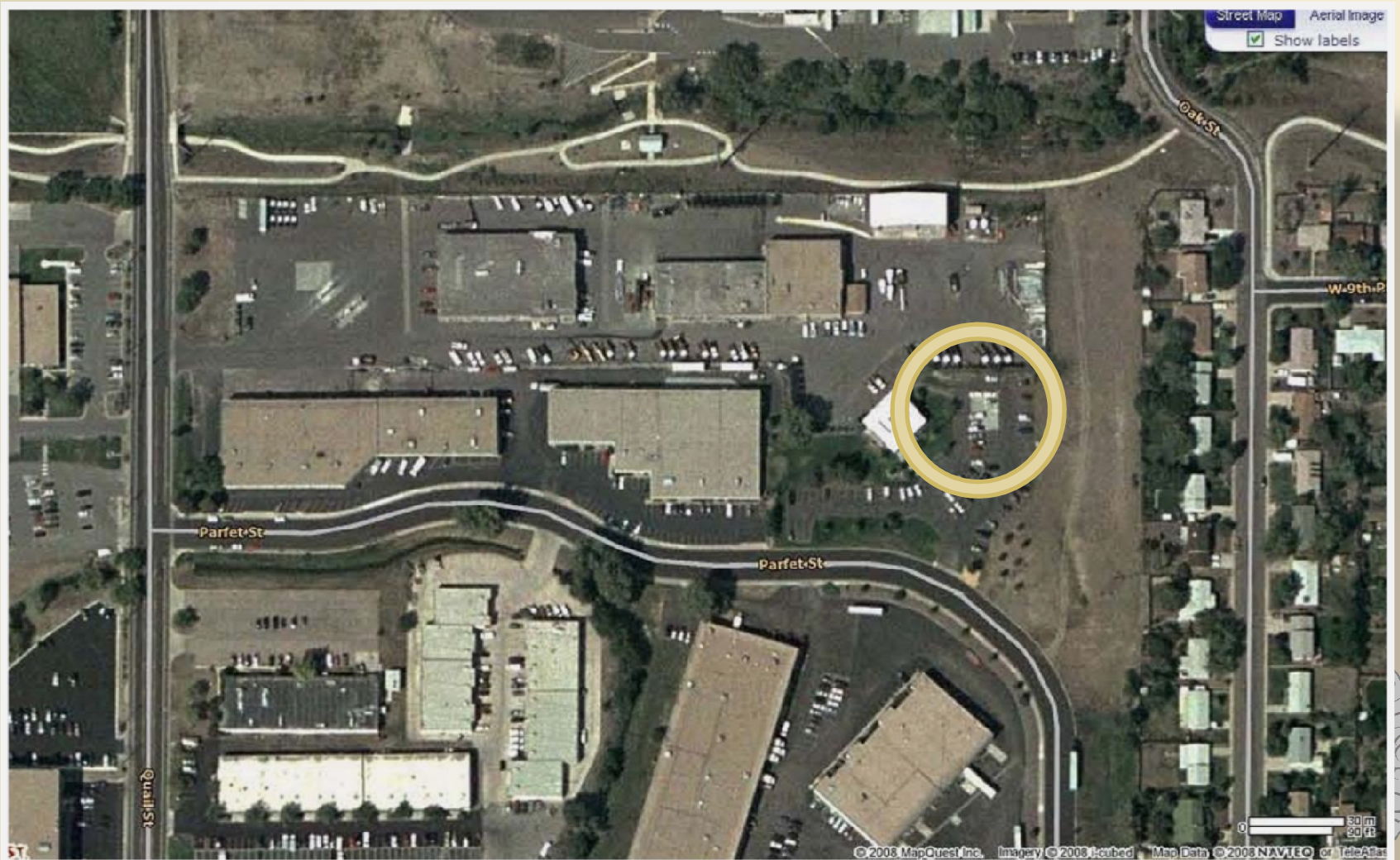


# Pervious Concrete Pavement

Spring 2005



# Municipal Maintenance Facility





# What's Wrong Here?

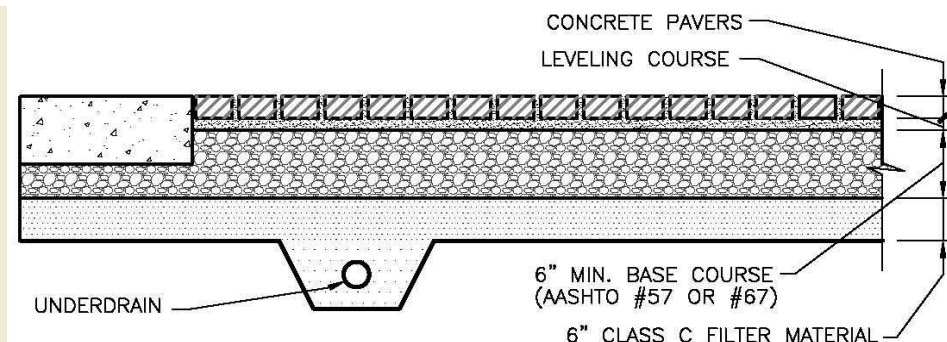
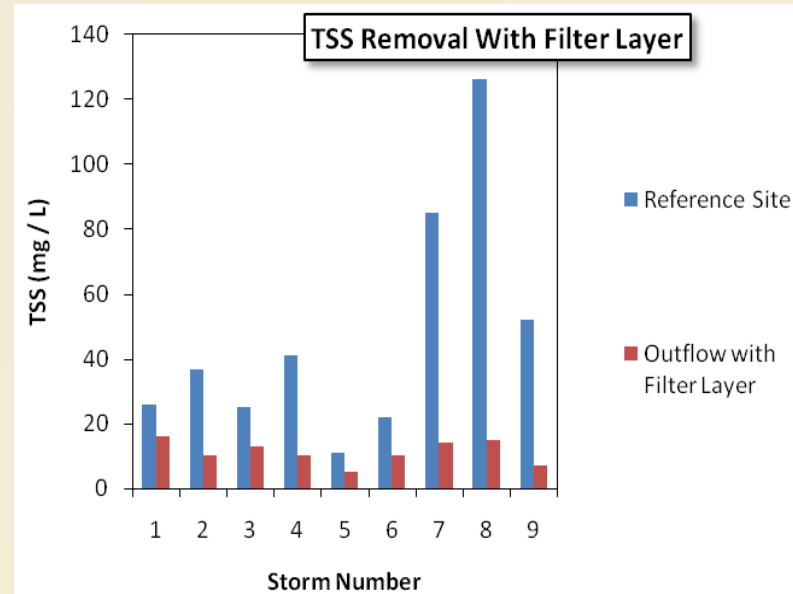
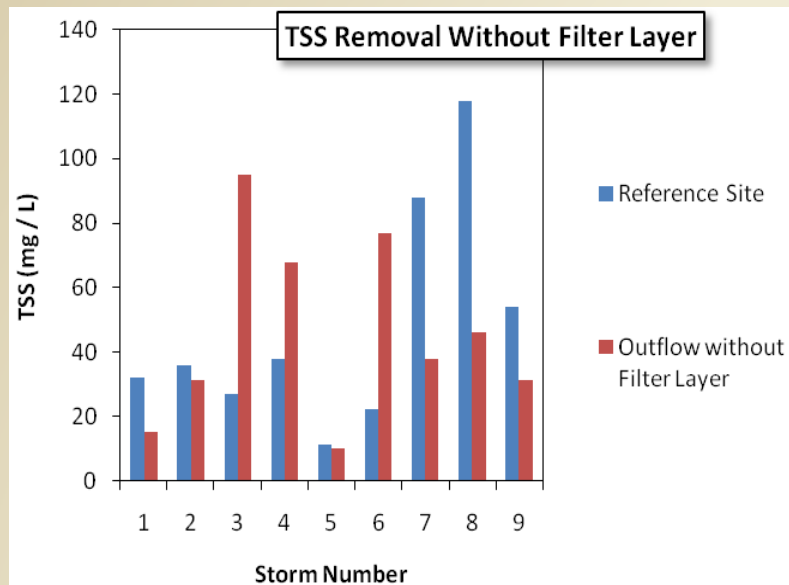




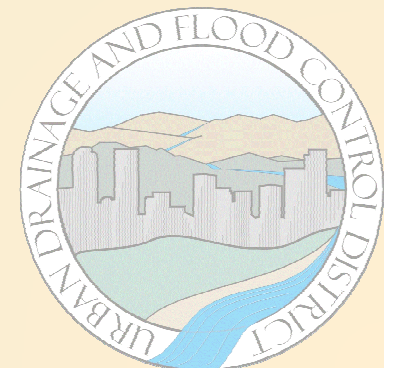
# What were we thinking?



# Permeable Pavement Filter Layer



**Pavement Section**





# Porous Asphalt Pavement

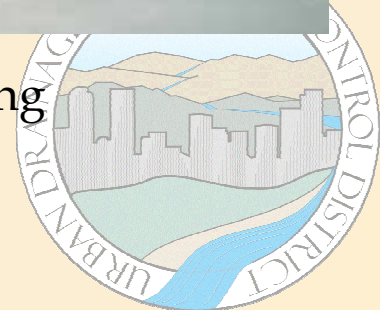
Spring 2008





Porous Asphalt

Permeable Interlocking  
Concrete Pavement



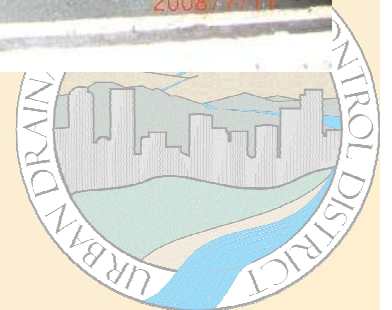


# Measuring Flow

ORIFICE TO MEASURE  
FLOW FROM PAVEMENT



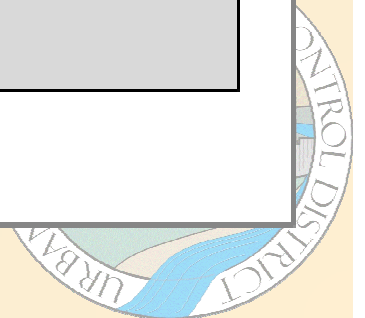
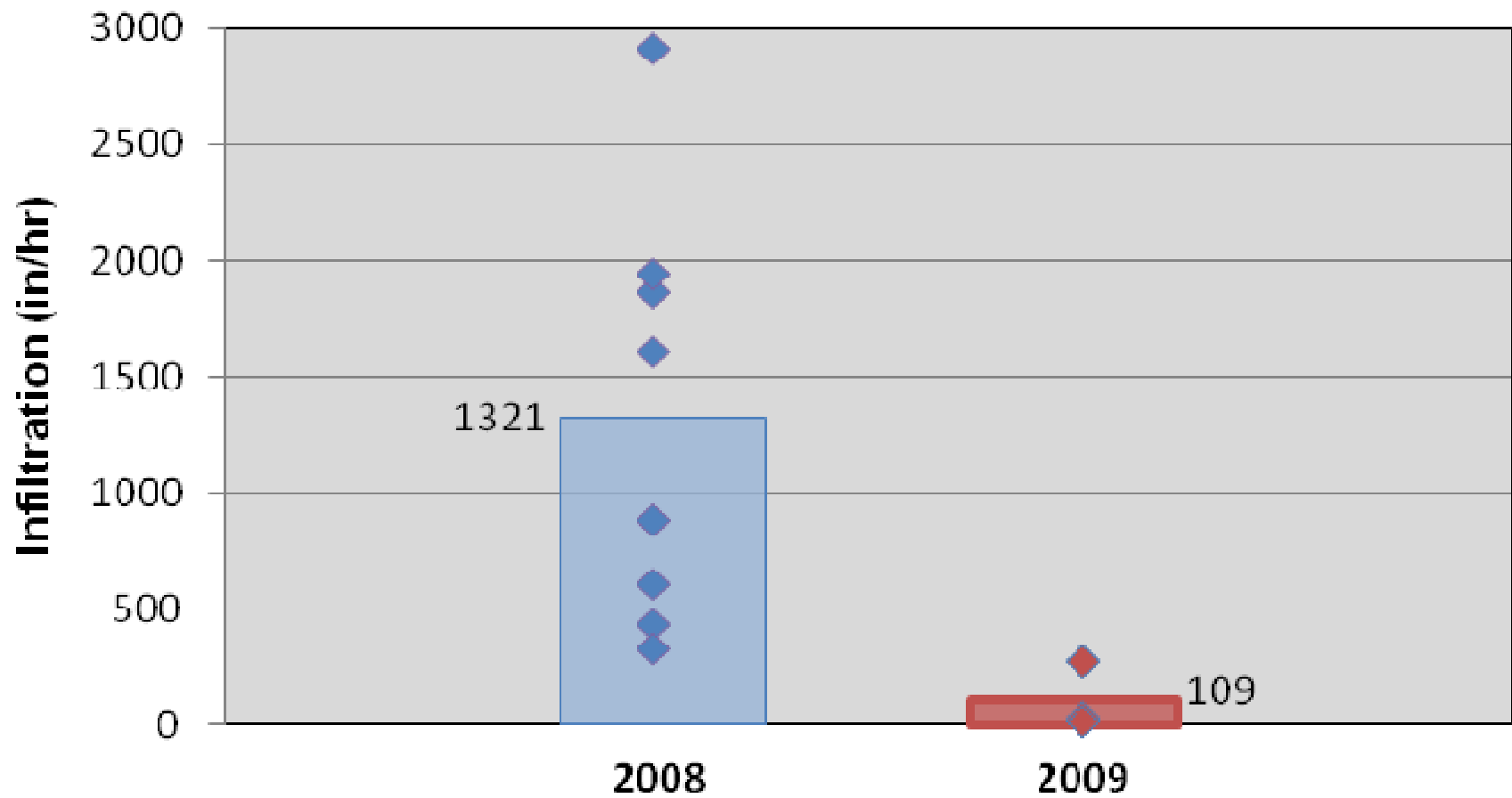
WEIR TO MEASURE  
FLOW LEAVING INLET



# Infiltration Tests



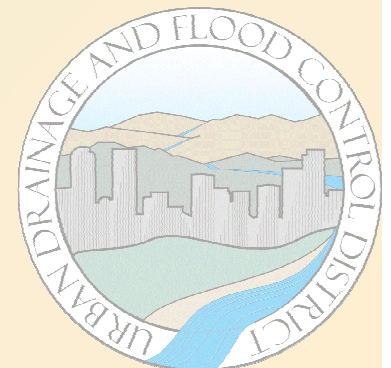
## Porous Asphalt Infiltration Tests







## MONITORING EQUIPMENT IN ISLAND

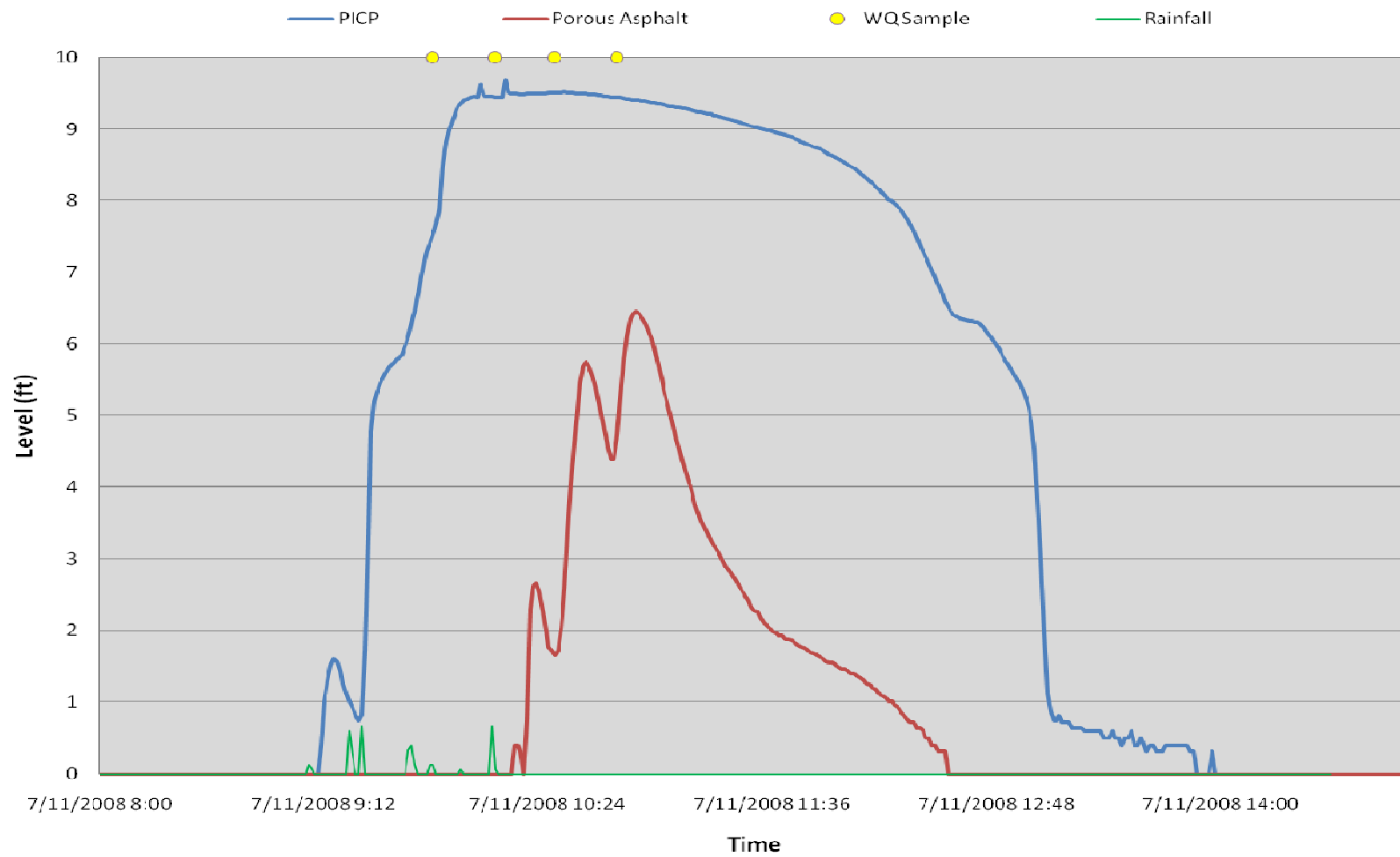


# Permeable Interlocking Concrete Pavers (PICP)

Spring 2008



## Performance Test Results





# www.bmpdatabase.org



The screenshot displays the homepage of the International Stormwater BMP Database. At the top, a green and blue logo depicts a city skyline and a winding water path. To the right of the logo, the text reads "INTERNATIONAL STORMWATER BMP DATABASE" and "www.bmpdatabase.org". Navigation links for "Contacts", "Policies", and "Disclaimer" are positioned in the upper right corner. A horizontal menu bar below the header contains links: "Project Sponsors", "Home", "BMP Performance Summaries", "Retrieve BMP Studies", "Research Tools/Master Database", "Data Entry Spreadsheets", "Monitoring/Evaluation", and "Publications".

**Project Sponsors:** Logos for WERF (Water Environment Research Foundation), ASCE (American Society of Civil Engineers), EWRI (Environmental and Water Resources Institute), EPA (U.S. Environmental Protection Agency), U.S. Department of Transportation Federal Highway Administration, and APWA (American Public Works Association) are listed vertically.

**Project Team:** Logos for WWE (Wright Water Engineers, Inc.) and Geosyntec consultants are shown.

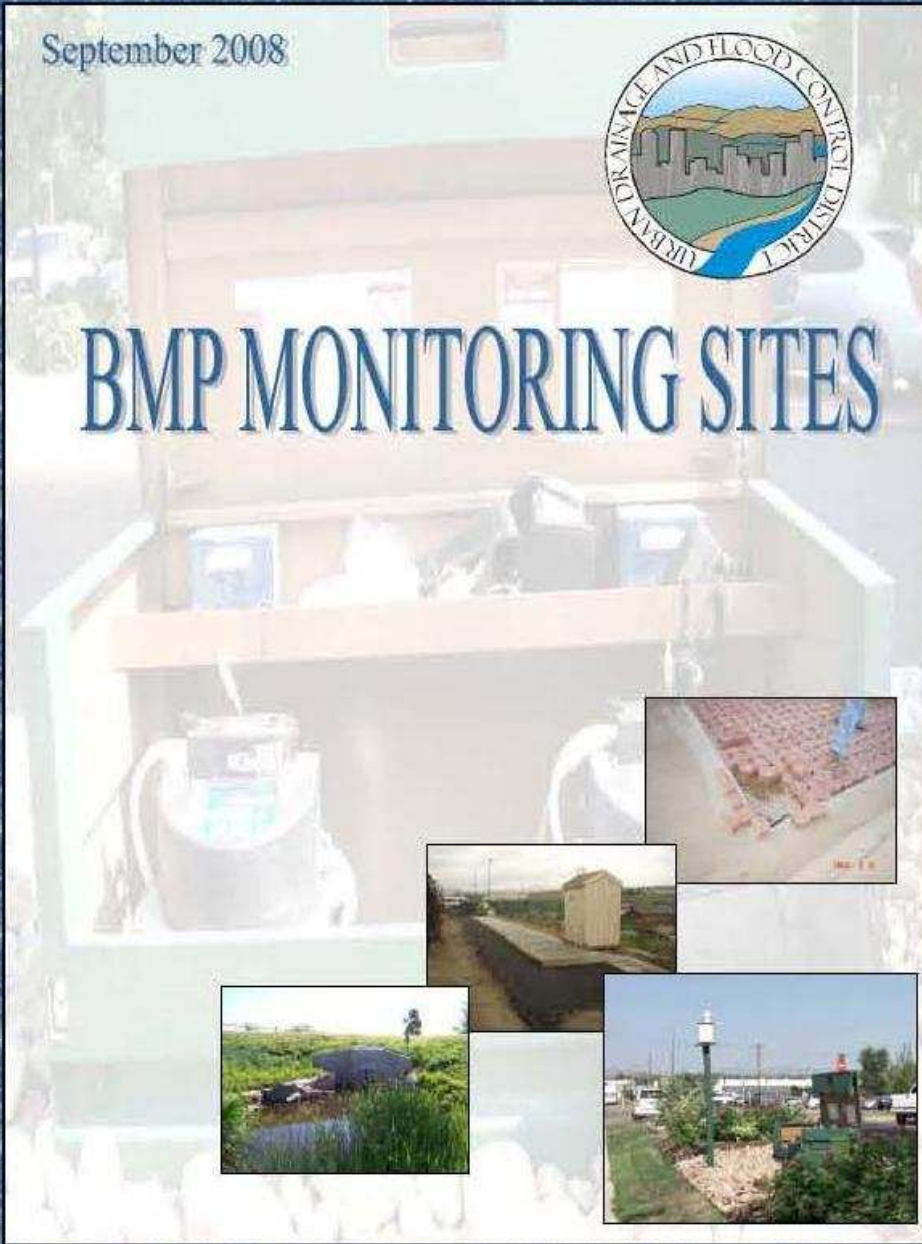
**Main Content Area:**

- Welcome:** A paragraph stating the website features a database of over 300 BMP studies, performance analysis results, and tools for BMP design, selection, and implementation. It mentions the project's goal to provide scientifically sound information and improve BMP design.
- Project Overview:** A paragraph detailing the project's history, starting in 1998 under a cooperative agreement between ASCE, USEPA, FHWA, and Geosyntec. It lists the entities maintaining and operating the database clearinghouse and web page.
- What's New:** A green box containing three updates: "Analysis of BMP Performance 2008", "Website revised with new, easy-to-use performance summary information", and "Master Database exceeds 300 BMP studies with access to a new bibliography".
- What Type of User Are You?:** A blue box with a link to "Let us help you enter our website to find the level of detail you need."
- User Categories:** Five green boxes provide guidance for different user types:
  - Low-Intensity:** Get Basic Performance Summary Information for BMPs. Typical Users: Public officials, casual users, those seeking quick/fast answers.
  - Mid-Intensity:** Get Detailed Statistical Analysis for Individual BMPs. Typical Users: Consultants, Public Works Staff, Designers.
  - Researcher:** Download the Master Database to Conduct Independent Research. Typical Users: University Professors.
  - Data Provider:** Obtain Data Entry Spreadsheets. Typical Users: Public agencies, consulting firms, university researchers.
  - New to BMP Monitoring:** Obtain Monitoring Guidance. Typical Users: Public agencies, consulting firms, university researchers, graduate students.

September 2008



# BMP MONITORING SITES







## UDFCD BMP MONITORING SITES Pervious Concrete Pavement

# PERVIOUS CONCRETE PAVEMENT



- Description
- Location
- Typical Details
- Installation
- Photo Gallery
- Monitoring Data
- Other Examples



## Description

### General



Pervious concrete pavement is a relatively new type of permanent surfacing. It is a monolithically poured pervious concrete pavement that has 15% to 21% of its volume as void. These voids within the concrete are achieved by **eliminating the fine sand** aggregate from the concrete mix. They provide the flow paths for rainwater from the surface of the pavement to the base course underlying it. Because the integrity of the concrete structure may be harmed by standing water during freezing weather, the use of pervious concrete pavement is **not recommended for use in pervious pavement detention** installations. It is critical that sufficient aggregate base course layer is provided under the pervious concrete slab to store the runoff and allow it to infiltrate slowly into the ground and drained using an underdrain pipe system. Having a sufficiently thick layer of aggregate base course is particularly critical during the months of the year when freezing of water can occur.

### Site Specific

The pervious concrete pavement site monitored by the District is located in Lakewood. Modular block pavement was monitored in this location from 1994-2004. **In 2005**, the modular block was replaced with the pervious concrete pavement that is currently in place. Two separate pads of pervious concrete pavement were placed using different aggregate sizes for the base course. The east pad used



## Photo Gallery

### Installation Photos – April 2005



Sand used for filter layer



Geotextile fabric above sand filter layer



AASHTO #67 base course



Spreading the concrete



AASHTO #67 mix



Rolling the concrete



#67 mix vs. #8 mix

### Current Condition Photos

April 2007 (2 years after install)



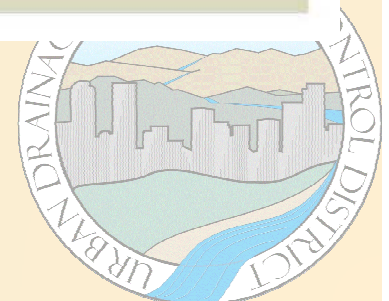
Concrete in good condition



Upper cell manhole and Levelogger riser



Lower cell manhole and Levelogger riser



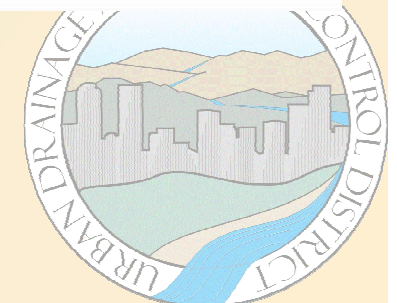
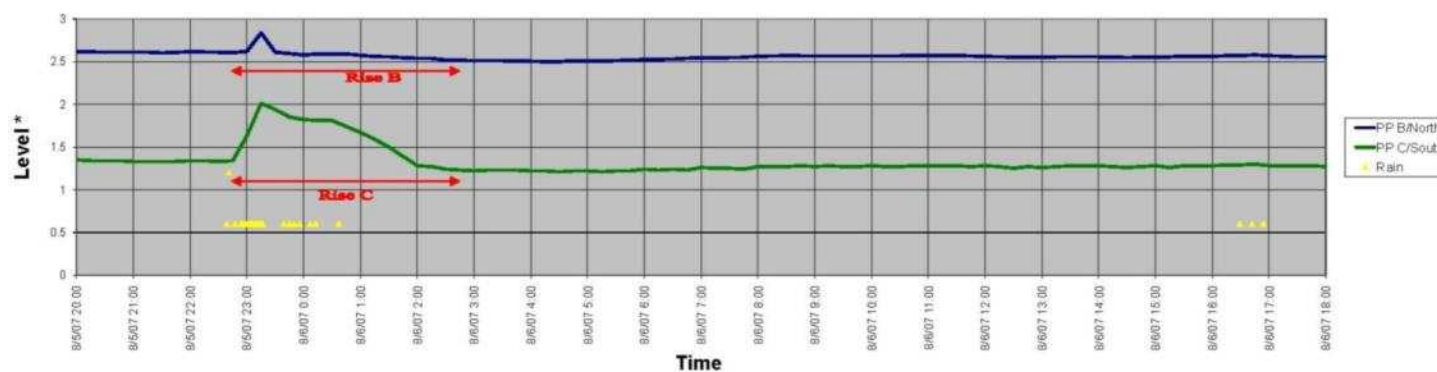
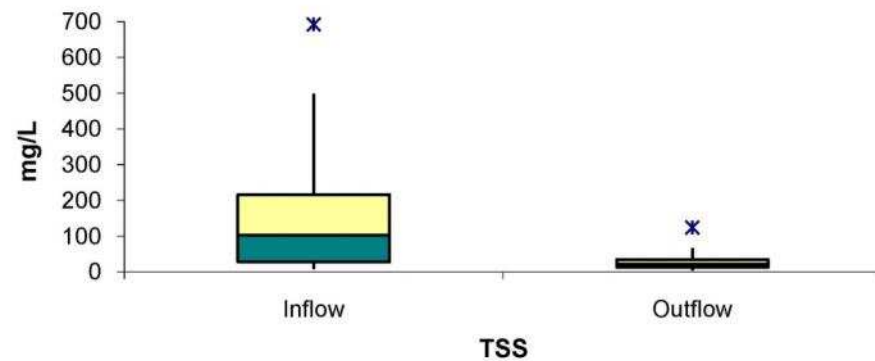


## Monitoring Data

### 2006 Flow Data Summary

Storm Number	Rainfall (in)	Start Time	End Time	Peak HF Depth (ft)	Peak VN Depth (ft)	WQ Samples?
1	0.31	4/6 555	4/7 941	0.113	0.142	no
2	0.16	4/27 417	4/28 1032	0.026	0.109	no
3	0.09	4/29 2250	5/1 712	0.042	0.125	yes
4	0.11	5/2 1820	5/5 1725	0.025	0.111	yes
5	0.34	5/8 2223	5/10 850	0.154	0.152	yes
6	0.05	5/19 1306	5/20 1625	0.057	0.04	no
7	0.03	5/21 2117	5/22 2211	0.033	0.033	yes
8	0.16	6/7 1324	6/8 1359	0.184	0.121	no
9	0.58	6/23 1833	6/24 2040	0.287	0.323	yes
Extra	N/A	7/4	7/4	N/A	N/A	yes
10	0.08	7/19 1624	7/20 851	0.136	0.129	no
11	0.03	7/22 2156	7/23 2204	0.049	0.046	no
12	0.05	7/24 1956	7/25 902	0.091	0.101	no
13	0.18	8/2 1455	8/3 1450	0.238	0.142	yes
14	0.07	8/4 1716	8/6 303	0.067	0.054	no
15	0.07	8/12 1943	8/13 1953	0.168	0.143	no
16	0.1	8/18 557	8/19 1857	0.106	0.112	no
17	0.05	8/23 1723	8/24 1135	0.119	0.113	no
18	0.15	8/25 639	8/26 1532	0.091	0.121	no
19	0.19	9/6 1710	9/9 1236	0.13	0.161	no
20	0.09	9/10 2036	9/11 2131	0.221	0.122	no
21	0.27	9/20 28	9/21 703	0.144	0.111	yes
22	0.05	9/21 2037	9/22 2049	0.248	0.138	no

### ORCHARD POND EDB 2002-2007





# www.udfcd.org



## Urban Drainage and Flood Control District

[Home](#) [Current Projects](#) [Downloads](#) [Calendar](#) [Resources & Links](#) [About Us](#) [FAQ's](#) [Mission Statement](#)

**Working with you since 1969**



### Flood Information

**Floodplain Map**  
Find out if you live in or near a floodplain. Search by address.

**Flood Safety Information**  
Protect yourself, your property and your family from flooding.

**ALERT System**  
Real-time flood detection and weather conditions.



### Flood Control Facilities

**Maintenance Eligibility**  
Local governments, businesses, organizations and individuals concerning the eligibility status of various projects reviewed UDFCD's Floodplain Management Program.

**Design, Construction and Maintenance**  
Detailed information about program activities



### Stormwater Quality

**Stormwater Quality**  
Research and Activities that promote the improvement of stormwater.

**Draft USDCM Volume 3 Documents**

### Board Meetings

April 15, 2010 - Board Meeting  
-Agenda  
-Resolutions  
-Meeting Minutes

Click [here](#) to view past board meeting information

### Recent News

- ∴ Sustainability on a large scale  
[Read more....](#)
- ∴ Flood Hazard News - District Construction Projects Win Awards. [Read more...](#)
- ∴ 2010 UDFCD Annual Stormwater and Floodplain Management Seminar  
Registration is now closed. [Click here](#) to view the seminar program
- ∴ FEMA issues revised fee schedule for processing map change requests, effective January 13, 2010
- ∴ District Adopts Westerly Creek Dam Development and Operation Regulations
- ∴ Moratorium on Porous Concrete Movement LIFTED
- ∴ Corrie Manual III updates coming soon. [Click here](#) for details.

Address: 2480 West 26th Avenue Suite 156-B Denver, CO 80211 | Phone: 303-455-6277 | Fax: 303-455-7880 [Contact Us](#)

hpiza@udfcd.org

